DOCUMENT RESUME

ED 188 888 SE 031 132

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TITLE Nice Girls Don't Study Mathematics. Final Report, December 1, 1977, through January 31, 1980.
INSTITUTION Institute for Research on Social Problems, Boulder, Colo.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
PUB DATE 80
GRANT NIE-G-78-0023
NOTE 72p.: For related document, see ED 174 477.

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Academic Achievement: Achievement: Aptitude: *Attitudes: Elementary School Mathematics: Elementary Secondary Education: Females: Mathematics Curriculum: *Mathematics Education: Mathematics Instruction: Secondary School Mathematics: *Sex Differences: Sex Role: *Sex Stereotypes: Stereotypes: *Student Attitudes: *Womens Education
IDENTIFIERS *Mathematics Education Research

ABSTRACT

This study investigated a variety of factors which influence the development of women's attitudes and performance in mathematics. Specific objectives were: (1) to document the existence of stereotypes associated with mathematics: (2) to determine the age at which children become aware of these stereotypes: (3) to specify the social agents transmitting stereotypic information: and (4) to determine the extent to which stereotypes affect both attitudes and achievement in mathematics. Toward these ends, three interrelated studies were conducted. The first study examined and compared women who obtained Ph.D.'s in mathematics, English, and psychology in terms of their backgrounds, beliefs, and attitudes. A second study investigated attitudes and achievement in mathematics among elementary school children. The third study determined the relation between attitudes and mathematics achievement in secondary school youth. Results revealed that: (1) stereotyped beliefs about mathematics are acquired early in the developmental process and are clearly present in elementary and secondary level students: (2) stereotyped information is transmitted by parents to elementary students, and by peers to secondary students: (3) males are more stereotyped than females: (4) there were no differences in mathematics achievement: and (5) degree of stereotyping was predictive for females and not for males. (MK)

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FINAL REPORT

Title: Nice Girls Don't Study Mathematics

Grant No. NIE-G-78-0023

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Abstract

Title: Nice Girls Don't Study Mathematics

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Grant No. NIE-G-78-0023

Relatively few females in the American labor force occupy positions involving higher mathematics, which results in a limitation of high-status career options for women. The present study investigated a variety of factors which influence the development of women's attitudes and performance in mathematics. Although different theories vary widely as to the types of factors underlying sex differences in mathematics interests and performances, the present investigators have placed particular emphasis upon cultural beliefs and values, particularly those designating the content of "appropriate" or "inappropriate" female roles. More specificially, the major objectives of this investigation were 1) to document the existence of stereotypes associated with mathematics, 2) to determine the age at which children become aware of these stereotypes, 3) to specify the social agents transmitting stereotypic information, and 4) to determine the extent to which stereotypes affect both attitudes and achievement in mathematics. Towards these ends, three inter-related studies were conducted.

The first study examined and compared women who obtained Ph.D.'s in mathematics, English, and psychology in terms of their backgrounds, beliefs and attitudes. A second study investigated attitudes and achievement in mathematics among elementary school children. Finally, the third study determined the relation between attitudes and mathematics achievement in secondary school youths.

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The results of this research program revealed that 1) stereotyped beliefs about mathematics are acquired early in the developmental process, and are clearly present in elementary and secondary level students, 2) stereotyped information is transmitted by parents to elementary students, and by peers to secondary school students, 3) males are more stereotyped than females, 4) there were no sex differences in math achievement, and 5) degree of stereotyping held was highly predictive of female math achievement scores, but not for males.

Taken together, the studies document the importance of sex-role stereotyping in shaping female attitudes towards mathematics. The implication of these results are particularly relevant for parents and educators. Since the data indicate that even middle grade-school children hold stereotypic beliefs about mathematics, parents and educators must become aware of what stereotypes they are transmitting if educational equity is to be accomplished. Although further research is needed to fully understand the transmission process, at the very least, both males and females should be expected to enroll in math courses, text books and other curriculum materials should be free from anti-female bias, and affirmative action policies should be implemented to increase the representation of women in math related fields. This problem is a pervasive one at all educational levels.

Women are seriously underrepresented in fields involving mathematics. The finding has been of concern to many, including educators, psychologists, and mathematicians. Most researchers who have dealt with this problem agree that women's lower participation in mathematics is a result of many factors. The cognitive, social and cultural influences involved interact in complex patterns and are extremely difficult to unravel.

The research to be described herein focused upon the role of socio-cultural factors. The basic assumptions underlying our research program were that: a) socio-cultural factors are transmitted primarily through parents, peers and the educational setting, b) these factors profoundly shape women's attitudes toward mathematics, and c) the attitudes subsequently affect women's performance in mathematics. This type of model is consistent with the views of current constructive theorists (such as Piaget) which assert that individuals construct their experience in accordance with their beliefs about reality. Many of these beliefs relate to what American society traditionally has deemed appropriate (or inappropriate) as roles for women. These cultural mores and dictums are transmitted in the form of sex-role stereotypes. As a consequence of accepting these stereotypes, women are directed away from mathematical pursuits.

Women are precluded from entering math-related fields because of three very different kinds of factors. The first includes external structural barriers, such as overt sex discrimination against women in educational, scientific and business institutions. The second involves social pressures from significant others such as parents and peers. Negative attitudes and feelings may be expressed either overtly or subtly, but their affect is the same. A final inhibiting source are the internal barriers--i.e., the internalized negative attitudes and beliefs about mathematics that women hold. The present study addresses these latter two factors.

In a recent review of the literature, Fox (1977) provides a persuasive case for the belief that women's lack of participation may be related to general sex role stereotyping. The existence of specific stereotypes about women in mathematics has been documented, although not extensively. Levine (1976) reported that girls do not perceive themselves as competent in mathematics even when they earn good grades in that subject. Similarly, Fennema (1974) noted that females rank themselves lower than males in mathematical ability even when they are out-performing males in math classes. Girls' self-concepts about their math ability, moreover, tend to decrease with age. Sex differences on self-confidence measures of math ability appear as early as the eighth grade (Kaminski, et al., 1976). Additionally, boys are particularly negative towards girls who demonstrate high levels of math proficiency (Levine, 1976).

There are striking differences in the degree to which males and females perceive the utility of mathematics. Hilton and Berglund (1974) maintain that measures of the perceived usefulness of mathematics differentiate the sexes as early as the ninth grade. These investigators also found a significant relationship between sex differences on math achievement tests and perceived usefulness of math for a career. There is also a suggestion in the literature that mathematicians are either masculine or perceived as masculine (Plank & Plank, 1954, Elton & Rose, 1967). The pattern here is far from clear-cut, however, since Jacobs (1974) and Lambert (1960) reported that high mathematics achievement in women is associated with a high level of femininity. These latter findings are puzzling and conflict with the results of Rossi (1965) and Luchins (1976) which showed that one of the primary reasons women do not pursue mathematics is fear of appearing unfeminine.

One problems with many earlier studies on sex-typing and mathematics is that they are based on out-dated conceptions of masculinity and femininity, which consider masculinity and femininity to be bipolar dimensions on a single continuum. Newer views hold that people can be more accurately described in terms of both masculinity and femininity (e.g., Bem, 1974, Spence & Helmreich, 1977). Measures have been developed which have separate masculinity and femininity scales. Persons obtaining high scores on both masculinity and femininity scales are referred to as psychologically androgynous. Persons obtaining high scores on the masculine scale and low on the feminine scale are classified as masculine, and those scoring high on the femininity scale and low on the masculinity scale are classified as feminine. Persons obtaining low scores on both scales are classified as undifferentiated. Bem and Lenney (1976) found that androgynous individuals have no difficulty in engaging in either traditionally masculine or traditionally feminine activities. Use of this newer conceptualization may help clarify some of the earlier obtained conflicting results. Consequently, the degree to which competence in mathematics is related to psychological androgyny was investigated in the present research program.

In spite of recent changes in the sex role attitudes in contemporary society, the goal of raising a family still retains the highest priority among American women. A study by Parelius (1975) found, for example, that only 28% of college women would forego having children for the sake of occupational success. Thus, even in a group of women described as liberal by the author of the study, family life was a more potent motivating force than career aspiration. To this end, women are usually encouraged to develop social skills in order to "catch" a husband, raise a family, etc. Qualities such as attractiveness, skill in personal interactions, and serving others

are culturally valued in women, and these qualities may well be instrumental for successful familial pursuits.

In present day society, women are entering the labor market with such frequency that the majority of high school and college females consider a dual career a definite possibility. Hawley (1971, 1972) and Astin (1974) concluded that marriage was the primary goal of most women; moreover, if they do elect a career, their choice is limited by what they feel men can tolerate.

A review of the literature suggests a number of beliefs about women and mathematics that seem to be culturally pervasive. It should be noted, however, that these beliefs may not be equally salient at all points in the developmental cycle. The various components of mathematical stereotyping are probably introduced at different times, and perhaps by different agents. Data indicate that males and females obtain approximately equal math achievement scores in elementary school (Maccoby & Jacklin, 1974). When students begin secondary school, males surpass females on mathematics achievement scores, and this male superiority increases with age (Mullis, 1975).

One of the primary purposes of the present research study was to document the existence of stereotypes associated with women and mathematics, and to specify the ages at which specific stereotypes exert maximal influence on female participation and achievement in mathematics. The study thus provides an in-depth developmental investigation of stereotyping in mathematics. The basic rationale underlying the research program is that sex-typing the field of mathematics as a masculine subject, combined with negative stereotyping of women in the field, are significant deterrents to increasing female participation in this area. Our research strategy was the following: first, to document the existence of stereotypes associated with mathematics; second,

to determine the extent to which children and adolescents in various age groups hold sex-role stereotypes about mathematics; third, to investigate the sources of these stereotypes; and, finally, to ascertain the effects of these stereotypes on mathematics achievement. In order to accomplish these aims, the research program was comprised of three separate studies. These included a study of female mathematicians, a study of children in elementary school, and a study of males and females at the level of secondary school. Each of these studies will be discussed separately.

Study 1: Female Mathematicians

In assessing the factors related to women's lack of participation in mathematics, one logical starting place is with female mathematicians themselves, since these women have overcome the cultural and psychological barriers which seem to prevent so many other women from entering the field. Thus, an investigation was undertaken to provide data concerning the specific personality and experiential characteristics which led these women to perservere in mathematics towards a successful career. In view of the fact that participation in mathematics seems to be profoundly affected by early experience, particular emphasis was placed on the influences of peers, parents, and the educational setting during primary and secondary school.

After a review of the pertinent literature and available instruments, a number of variables were selected for assessment. When available, existing instruments were examined and chosen, based on adequate face validity and other psychometric properties of those instruments. In those cases where no adequate instruments were available, items were developed and piloted. The pilot questionnaire was mailed to female students and faculty in the Mathematics Department and the School of Education at the University of Colorado. A revision of this questionnaire was undertaken based on the

comments and responses of the pilot subjects. The final questionnaire included background information (employment status, place of employment, number of siblings, influences of parents, peers and teachers in math, perceived ability of parents in math) and personality measures, including the Bem Sex Role Inventory (Bem, 1974), the Spence Attitudes Toward Women Scale (Spence & Helmreich, 1975), a measure of locus of control, and a measure of theoretical and social values based on Allport, et al. (1960). A major section of the questionnaire was devoted to questions about stereotyping in their fields. Respondents were asked if society stereotypes women in their fields, the nature of these stereotypes and the degree to which stereotypic beliefs may be changing (see Appendix).

Questionnaires were mailed in May 1978 to women throughout the country who had obtained Ph.D.'s in mathematics, English and psychology during the past ten years. English was chosen as a representative of a traditionally "feminine" field, and psychology was chosen as a representative of a field traditionally typed as neither "masculine" nor "feminine". After mailing out about 1000 questionnaires, we received a total of 460 completed questionnaires: 279 from mathematicians, 90 from English Ph.D.'s and 91 from psychologists. Response rates were as follows: 42% for the mathematicians, 52% for the psychologists and 50% for the English Ph.D.'s. The total response rate was 45%. Since our primary goal was to investigate mathematicians, we over-sampled women in this area.

Results of Study 1

One of the primary goals of the study was to determine the degree to which the respondents believed that society stereotypically characterized women in their fields. The response of all three groups indicated a high frequency of stereotyping associated with women in all three fields: 82.8% of the mathematicians responded that women are stereotyped in their field,

TABLE 1

PERCENTAGE OF FEMALE PH.D.'S INDICATING THAT SOCIETY STEREOTYPES WOMEN IN THEIR FIELDS ($p < .01$)*

	YES (%)	NO (%)
MATHEMATICS ($n = 274$)	82.8	17.2
ENGLISH ($n = 88$)	73.9	26.1
PSYCHOLOGY ($n = 91$)	64.8	35.2

*FIVE MATHEMATICIANS AND TWO ENGLISH PH.D.'S DID NOT RESPOND TO THIS ITEM.

whereas 73.9% of the English Ph.D.'s and 64.8% of the psychologists indicated society stereotypes women in their field (see Table 1). Differences in these response patterns were highly significant ($p < .01$) as tested by Chi square.

On another item, the respondents were asked if society characterized their fields as masculine, feminine or neutral. The majority of the mathematicians indicated that society considers their field to be "decidedly masculine", whereas the English Ph.D.'s indicated that society considers their field "somewhat feminine". Most of the psychologists indicated that society considers their field neither masculine nor feminine. An analysis of variance indicated that differences among the groups were highly significant ($F = 294.30$, $p < .01$). Note that mathematics was the field considered by the women to be most masculine and was also the field associated with the highest degree of stereotyping.

The respondents were asked to list the specific stereotypes associated with women in their fields. A list of the ten most frequently named stereotypes for each field is shown in Table 2. An inspection of these lists indicate that the stereotypes associated with women in psychology do not appear to be as negative as the stereotypes in the other two fields. Notice also that the stereotypes "masculine" and "unfeminine" are ranked higher for the mathematicians. The stereotype "masculine" is ranked fifth for the psychologists and does not appear in the top ten list for the English Ph.D.'s. The word "unfeminine" does not appear in either the psychologists' or English Ph.Ds' top ten list. Mathematics, then, is a field perceived by society as a masculine field and women entering this field are characterized as masculine and unfeminine. On another item, the respondents indicated that the stereotypes they had listed were generally inaccurate characterizations of women in their fields and, importantly, that these stereotypes were becoming somewhat weaker.

TABLE 2

STEREOTYPES PERCEIVED BY FEMALE PH.D.'S IN THREE AREAS

	MATHEMATICIANS	ENGLISH PH.D.'S	PSYCHOLOGISTS
1.	UNATTRACTIVE	OVERLY-INTELLECTUAL	AGGRESSIVE
2.	MASCULINE	UNATTRACTIVE	NOT AS COMPETENT AS MEN
3.	COLD/DISTANT	OLD MAID	INTERESTED IN CHILDREN
4.	UNFEMININE	OUT OF TOUCH WITH REALITY	INTERESTED IN HELPING PEOPLE
5.	INTELLIGENT	AGGRESSIVE	MASCULINE
6.	OVERLY-INTELLECTUAL	OBSESSED WITH PROPER GRAMMAR	ANALYTICAL
7.	INCOMPETENT COMPARED WITH MALES	NOT SERIOUS	COLD/DISTANT
8.	AGGRESSIVE	PICKY	INTELLIGENT
9.	SOCIALLY AWKWARD	NON-DOMESTIC	MANY PERSONAL PROBLEMS
10.	ANALYTICAL	NON-SEXUAL	CAN READ YOUR MIND

The women were asked to indicate the source of stereotypic information. That is, who in their environment first provided knowledge about the content of stereotypes about women in their professions. The results were similar for the three groups. The respondents felt that their peer groups were the primary source of stereotypes, particularly the male peer group. Family members were less often named as a source of stereotypes than either the media or peer groups. (Only 5% of the mathematicians indicated that their fathers were sources of stereotypes, whereas 14.4% of the English Ph.D.'s and 11% of the psychologists indicated that their fathers were sources of stereotypes.) When asked at what age they became aware of these stereotypes, most of the respondents indicated that they learned these stereotypes in junior or senior high school.

The respondents were asked to specify the age at which they decided to pursue careers in their fields. There was an indication that the mathematicians became interested in pursuing a career in mathematics at a relatively early age. By their senior year in high school, 40% of the mathematicians had decided on careers in mathematics, while only 27% of the English Ph.D.'s and 23% of the psychologists indicated that they had reached career decisions. This finding may well be a reflection of the intensity of interest these women had in mathematics, as well as the fact that psychology is not usually included in the course curriculum in most high schools.

This finding is consistent with other literature which indicates that women who pursue careers in mathematics show an early and intense interest in the subject matter (e.g., Jacobs, 1974). On several open-ended questions, the mathematicians indicated they received a high degree of support from their families in their career decisions. Thus, the families of these respondents may have provided them with enough support and encouragement so that they

could pursue their careers in spite of any negative stereotyping on the part of their peers.

Bem Sex Role Inventory

Included in the questionnaire test battery packet was the Bem Sex Role Inventory (Bem, 1974). Looking at the masculinity, femininity and social desirability scales separately, Chi squares indicated that the mathematicians were the least masculine, followed by the psychologists and English Ph.D.'s ($p < .01$). There were no differences among the three groups on the femininity or on the social desirability scales ($p > .10$).

When the masculinity and femininity scales are considered simultaneously using the median-split technique described by Spence and others (Spence, et al., 1975), subjects were placed into four categories: masculine, feminine, androgynous or undifferentiated. Differences in the frequencies of women in the three fields who fell into the four categories were tested by Chi square and were highly significant ($p < .01$). The percentages of women who fell into each category are shown in Table 3. From this table it appears that the English Ph.D.'s fall with greater frequency into the androgynous category and with less frequency into the undifferentiated group, compared with the mathematicians and psychologists. It also appears that the psychologists fall into the masculine category with less frequency than either the mathematicians or the English Ph.D.'s. There are no significant differences among the three groups in the feminine category.

The results of the Attitudes Toward Women measure indicated that the women in all three fields were liberal in their attitudes toward the roles of women in society ($p < .01$). The female mathematicians were slightly less liberal than the women in the other two fields. On the locus of control measure, the English Ph.D.'s were slightly more external and the psychologists

TABLE 3

CLASSIFICATIONS OF THREE GROUPS BASED ON
BEM SEX-ROLE INVENTORY
MEDIAN-SPLIT TECHNIQUE ($p < .01$)

Ph.D.'s	Masculine	Feminine	Androgynous	Undiff.
Mathematics	26.8	25.2	20.1	28.0
English	24.7	21.2	38.8	15.3
Psychology	16.3	24.4	31.4	27.9

were slightly more internal than the women in the other two groups ($p < .01$). As expected, the female mathematicians revealed a greater degree of theoretical interests ($p < .01$) than the women in other groups. This latter finding is consistent with other literature (e.g., Fox, 1977) which suggests that female mathematicians may be somewhat more theoretical in orientation than women in other fields.

These findings may be summarized as follows:

1) Women in mathematics, English and psychology perceive that society stereotypes women in their fields.

2) Women mathematicians perceive a stronger degree of stereotyping than do women in English and psychology.

3) The women in the three groups felt that stereotypes were becoming somewhat weaker. This belief was particularly true for the female mathematicians.

4) The peer group in junior and senior high school may be the primary source of stereotyping.

5) Women in mathematics make relatively early career decisions.

6) Women in English may be more androgynous than women in psychology or mathematics.

Study 2: Elementary School Males and Females

The second study was concerned with documenting the ages at which children begin labelling mathematics as a subject belonging in the male domain, and to determine the relationship between attitudes and achievement in mathematics at the level of elementary school.

A questionnaire was developed and administered to 562 children in grades 3-6 in the Boulder Valley School District. Boulder has a predominantly white

and middle class population. The questionnaire contained an instrument assessing spatial ability, the Hidden Patterns Test (French, 1963), items assessing children's beliefs and attitudes about mathematics, and sex-typing measures. Achievement and aptitude scores in mathematics were taken from the McGraw Hill Test of Basic Skills. This test is routinely administered to students in Boulder each year as part of an annual testing program.

Achievement Scores

The total mathematics achievement score is comprised of scores from three subtests: computation, concepts, and applications. An analysis of variance indicated that there were no sex differences on total scores in mathematics.

Masculinity and Femininity

A measure of sex-role flexibility was developed which was based on Bem's (1974) notions of psychological androgyny. Instead of using personality traits as measures, it was decided that preferences for toys and activities would be more appropriate for children. After pilot testing, a list of 20 toys and activities was compiled which represented approximately equal numbers of "boy preferred" and "girl preferred" toys and activities. The instrument consisted of items such as train set, doll, drum, ice skating, and chess. The children were asked to do two things with these lists. First, they indicated who usually prefers each toy or activity: boys, girls, or both boys and girls. This measure is called the Toys Classification Test. Second, the children were asked to indicate on a three point scale how much they liked the toy or activity. This measure is called the Toys Preference Test. The data from this latter measure were factor analyzed in order to create masculinity and femininity scales. The items which formed factor 1

appeared to be related to femininity. On the Toys Classification Test, each of these items in factor 1 had been classified by the children as preferred by girls. The items which made up this factor were scale scored and became the measure of femininity. Factor 2 appeared to be a "masculinity" factor. On the Toys Classification Test, each of these items had been classified by the children as items preferred by boys. The items which made up this factor were scale scored and became the measure of masculinity. A Chi squire indicated that boys preferred the masculine toys and girls preferred the feminine toys ($p < .01$).

Using the median-split technique, each child was classified as masculine, feminine, androgynous or undifferentiated. The majority of the males fell into the masculine category and the majority of the females fell into the feminine category. 5% of the males were classified as feminine and 4% of the females were classified as masculine. The remaining children were approximately equally divided between the androgyny and undifferentiated categories. (For the males, combined across the four grades, 67% were classified as masculine, 5.4% were feminine, 14% were androgynous and 15% were undifferentiated. For the females, 4% were classified as masculine, 67.4% were feminine, 17% were androgynous and 12% were undifferentiated.) When inspecting the data for the younger and older children separately, both boys and girls became slightly less feminine and slightly more masculine with age. There were no increases with age in the number of children classified as androgynous.

The data contained a second measure of sex role flexibility. As mentioned previously, the children were asked to classify each toy or activity as preferred by boys, girls, or both boys and girls. It was decided to consider the "both" category as a measure of sex-role flexibility. If the child

considered that both boys and girls preferred the toy or activity, then the child is showing an absence of strict sex role stereotyping. One interesting finding in comparing boys and girls on this measure is that girls more often categorized masculine toys as preferred by "both" boys and girls. This tendency increased with grade. For the boys, the number of instances in which they classified a masculine toy or activity as "both" remained the same with advancing grade. Thus, on this measure, girls seem more flexible in their sex-role orientation, and this flexibility increases with age.

Attitudes Toward Mathematics

As a first step in constructing the math attitude scales, a factor analysis was performed on the majority of attitude items. Five items related to personal attitudes toward math combined to form the first factor. These items included liking of math, interest in math, enjoyment of math, perceived difficulty of math, and whether or not math was their best subject. These items were scaled and became the Math Attitudes Scale-Elementary. The results of an analysis of variance indicated that both boys and girls appear to be at the same level of liking math in grades 3 and 4. The boys continue liking math to this same degree in grades 5 and 6. The girls, however, decline somewhat during grades 5 and 6 ($p < .03$).

A second set of items related to peer attitudes toward math formed factor II: Peer Math Attitudes. An analysis of variance indicated no grade or sex main effects. There was a suggestion that girls perceive a decline in their friends' liking math with grade ($p < .09$).

Mathematics in the Male Domain

Do elementary school children consider math to be in the male domain? When addressing this question, a distinction must be made between children's stereotyping of math among adults and their stereotyping of math among their

peers. When the children were asked about math abilities among their peers, in general, girls responded that girls are better in math and boys responded that boys are better in math. With age, however, the girls begin to shift toward favoring the boys. As a comparison, the children were asked who is better in reading, boys or girls? Although there was a slight shift among the girls toward favoring the boys, the change with age in the girls' perceptions of reading ability is not nearly as dramatic as the change that occurs in mathematics.

These children revealed a markedly different pattern in the questions about mathematics in the adult world. Two questions were asked about adult ability in math and one question about usage of a hand calculator. On the responses to an item asking whether men or women are better at filling out an income tax form, children of both sexes indicated that adult males are more competent than adult females. On the item which asked who could work with numbers better, children of both sexes agreed that adult males were more competent, and the boys were stronger in this belief ($p < .01$). Clearly the children consider adult males to be more involved with math, as demonstrated by greater usage of a hand calculator, and as being far more capable than adult women in mathematics. On these items, both boys and girls, and not just the boys, consider math to be in the male domain. There were no significant changes with grade in these perceptions.

The children's responses to the three items which dealt with stereotyping in the adult world were summed and became scores on the Stereotyping Adults Scale.

Attitudes and Math Achievement in Elementary School

When predicting math achievement scores using a hierarchical regression model, the Non-language Aptitude score was the strongest predictor for both boys and girls. Math achievement scores were predicted on the basis of some

of the personality variables to a small, but significant degree. Attitudes toward Math entered into the regression equation more strongly for the boys than for the girls.

Sex Role Flexibility and Math Achievement

Classification into the four sex role categories (masculinity, femininity, androgyny, undifferentiated) was not related to math scores. There are other indications, however, that sex-role flexibility may be related at least to some degree to higher math scores for females. In a hierarchical regression analysis, subjects' masculinity (M) score was entered into the equation, then femininity (F) score, and then their M x F score, as suggested by Cohen (1968). For the females, the M x F score significantly predicted math applications ($p < .01$), and predicted the total math score with marginal significance ($p < .07$). The masculinity and femininity scores by themselves did not predict math scores for the females, but the relative performances of the two measures (which may be conceptualized as psychological androgyny) was of some predictive utility.

Stereotyping and Math Achievement

When the correlations between math achievement and stereotyping were examined, the results were dependent on sex of the child. For girls, the more stereotyping of adults in mathematics, the lower the math achievement level ($p < .05$). For boys, there was no significant correlations between stereotyping of mathematics at the adult level and math achievement scores. Thus, it would appear that stereotypes affect girls more adversely.

On the basis of this study, it may be concluded that: 1) attitudes seem to affect students' mathematics achievement scores in elementary school, 2) sex differences emerge in children's attitudes toward mathematics, although there were no over-all sex differences in math achievement scores, and

3) even third grade children perceive math to be in the male domain in the adult world.

In summary, it is clear that considerable stereotyping is associated with mathematics in grade-school children, and that this stereotyping begins at relatively early developmental levels. Socio-cultural factors are already playing an important role.

Study 3: Junior and Senior High School Study

In order to investigate attitudes and achievement in mathematics at the junior and senior high school level, we collected both attitudinal and achievement scores data from 279 males and 314 females in grades 7, 9 and 11 in two junior and two senior high schools in the Boulder Valley School District. The sample included 593 subjects: 109 males and 110 females in the seventh grade ($\bar{x}$ = 12 yrs., 0 mos.), 133 males and 153 females in the ninth grade ($\bar{x}$ = 15 yrs., 4 mos.), and 37 males and 51 females in the eleventh grade ($\bar{x}$ = 17 yrs., 1 mo.). The overall participation rate was 34.7%, and was largely attributable to a low participation rate for the eleventh grade. School officials subsequently informed us that students of this age in Boulder Valley are reluctant to participate in volunteer testing programs.

Methodology

The methodology in the junior and senior high school study was similar to that of the elementary school study. A questionnaire was developed assessing attitudes toward mathematics, stereotyping in mathematics, perceived usefulness of mathematics, peer influences, independence, math background, occupational preferences, family aspiration, and general personality traits (expressiveness, physical bravery, intellectual achievement, and negative self-concept). The questionnaire was balanced so that there were

equal numbers of positive and negative items. Thus, there was no bias toward stereotypic statements in the questionnaire.

After parental permission was obtained, questionnaires were administered to students in April 1978. Students were tested in small groups during school hours.

As in the elementary school study, both achievement scores and aptitude scores were taken from the McGraw Hill Test of Basic Skills. This test is administered to students in primary and secondary school each year as part of Boulder Valley's annual testing and evaluation program. Because the McGraw-Hill test battery is administered to a limited number of students, we were able to obtain achievement data for 91.2% of the students who completed questionnaires. Data was provided in the form of percentiles as well as scale scores. That is, each student's mathematics achievement score was represented by a scale score (a normalized raw score) and a percentile based on national norms. The breakdown by grade and sex of those students on which achievement data was obtained were as follows: 7th grade, males = 88, females = 94; 9th grade, males = 129, females = 142; 11th grade, males = 27, females = 49.

An analysis of variance was performed on the achievement scale scores in mathematics. There were no significant sex differences for the three subscales (computation, concepts and applications) or for the total scores. Because scale scores are designed to increase with grade, in order to compare students in the three grades on math ability, it was necessary to use percentile socres as a dependent measure. An analysis of variance revealed a significant grade main effect ($p < .01$), with the percentile means for the seventh grade equalling 77%, ninth grade equalling 74%, and the eleventh grade equalling 65%. The entire sample is well above average in comparison

with students across the nation. Although the eleventh grade sample is below the other groups in terms of math ability, these scores relfect the same pattern of scores obtained for students at these grade levels in the entire district.

Questionnaire

Each of the personality scales were developed in a similar manner. First, relevant literature was reviewed, existing scales were examined, and items were selected which either showed high degrees of reliability or seemed to the principal investigators to have a high degree of face validity. Other items were written and included if necessary. These items were administered to a pilot sample of seventh and ninth graders, and the data factor analyzed to determine which items formed independent scales. Only those items which factored together to form discrete scales were included in the final questionnaire. After the data was collected from our final sample, it was again entered into a factor analysis. In general, the same factors which emerged from the pilot sample emerged as factors of the data from the final sample. Thus, scales have been validated factorially using two separate samples. The resulting factors were scaled and used as our measuring instruments. The final scales are presented in the Appendix.

Math Attitude Scale

The final Math Attitude Scale was comprised of 12 items. Responses were based on a five-point Likert scale format ranging from "strongly agree" to "strongly disagree". The Math Attitude Scale was comprised of two measures: math anxiety and task competence motivation. Task competence motivation is defined as a student's motivation to achieve the demands of the task (Veroff, et al., 1975). Math anxiety is defined as uneasiness or fear associated with situations involving mathematics. Since these measures

appear to be conceptually distinct, several data analyses were carried out using the two subscales separately.

On the Task Competence Motivation subscale, an analysis of variance revealed significant grade ($p < .023$) and sex differences ($p < .05$). The sex x grade interaction was not significant. An examination of the means indicated that boys had a higher level of task competence motivation than the girls at all grades, and that task competence motivation generally declined with grade for both the boys and girls. The boys showed an increase between the ninth and eleventh grades. On the Math Anxiety subscale, an analysis of variance showed significant grade ($p < .029$) and sex differences ($p < .041$). The sex x grade interaction was not significant. Math anxiety was higher for the girls than the boys at all grades and decreased for both boys and girls with grade. Since factor analyses of the data did not reveal a factorial distinction between task competence motivation and math anxiety, these two subscales were combined to form the Math Attitudes Scale.

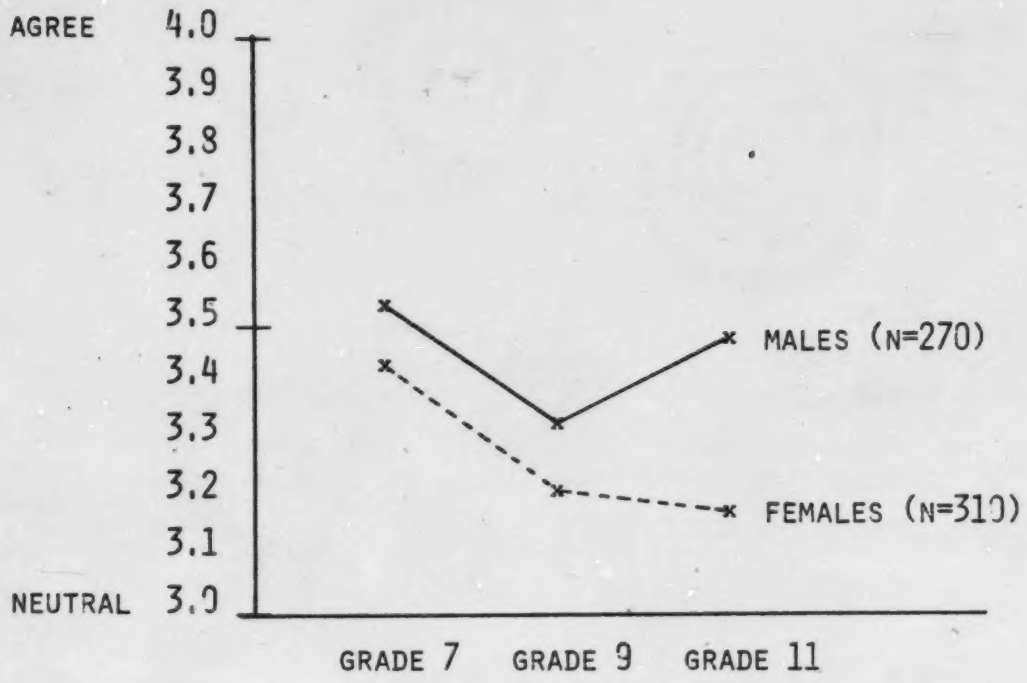
An analysis of variance which was performed on the data from the total Math Attitudes Scale showed significant grade ($p < .029$) and sex ($p < .017$) differences. The sex x grade interaction was not significant. An examination of the means indicated that boys showed more positive attitudes toward math than the girls, and that both boys and girls became slightly less positive toward math with increasing grade level (see Figure 1). The eleventh grade males were more positive toward math than the ninth grade males.

Stereotyping in Mathematics

The Math Stereotyping Scale was comprised of eleven items representing male stereotyping in math, competence of women in math, math as a male domain, and femininity of female mathematicians. Each item was presented with a

Figure 1

MATH ATTITUDE SCALE--TEENS



ANALYSIS OF VARIANCE:

SEX $F=4.78$ $p < .029$

GRADE $F=4.11$ $p < .017$

INTERACTION: NOT SIGNIFICANT

five-point Likert format ranging from "strongly agree" to "strongly disagree". An analysis of variance indicated significant grade ($p < .01$) and sex differences ($p < .01$), with the males showing higher levels of stereotyping than the females, and stereotyping for both males and females lower for the students in ninth grades than students in the seventh or eleventh grades (see Figure 2). The eleventh grade males showed the highest level of stereotyping.

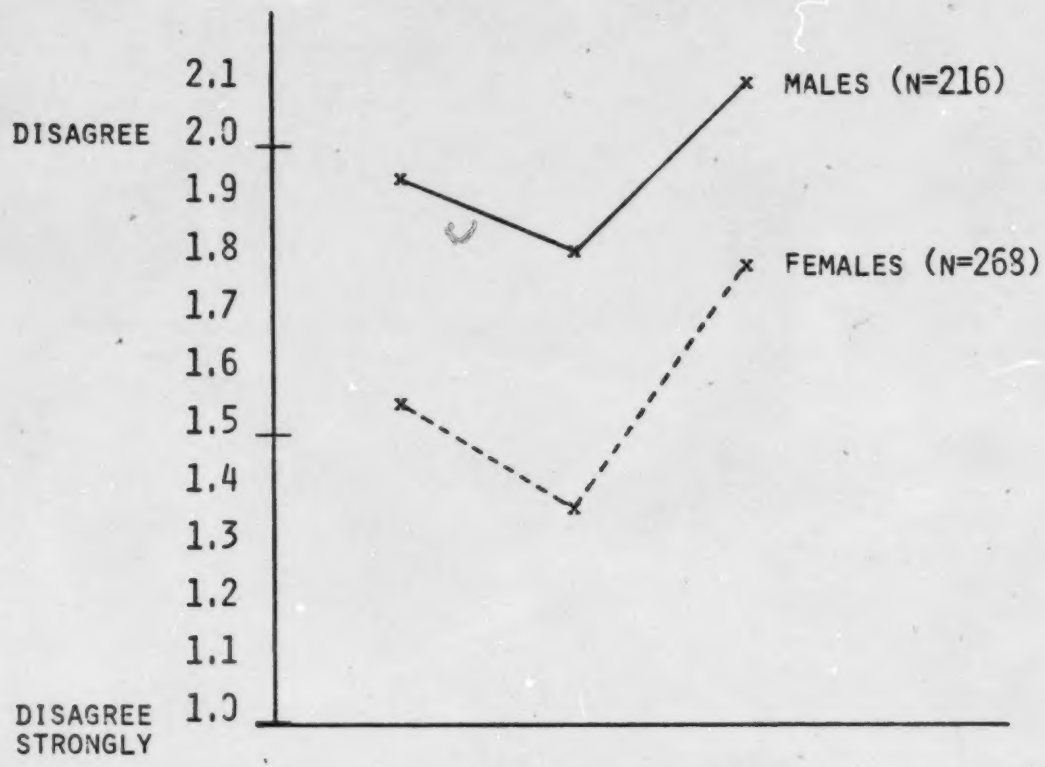
Occupations

This measure was comprised of two subscales: male occupations and female occupations. A list of occupations was given to a pilot sample of seventh and ninth grade students. Students were asked to indicate which occupations are usually performed by men, which are usually performed by women, and which were usually performed by both men and women. In addition, students were asked to rate their degree of interest in each occupation on a five-point Likert scale. These scores were entered into a factor analysis which yielded two separate factors. One factor was comprised of occupations that students indicated are usually performed by men, and one factor was comprised of occupations that students indicated are usually performed by women. Scores from the items on the two factors were scaled. The items on the Male Occupation Scale included: engineer, bus driver, police officer, real estate sales, accountant, mathematician, and plumber. The Female Occupation Scale was comprised of: social worker, dancer, head nurse, English professor, writer, secretary, and bookkeeper.

After this measure was administered to the final sample, an analysis of variance by grade and sex was performed on the Male Occupations Scale which indicated that the males were significantly more interested in these

Figure 2

MATH STEREOTYPING SCALE--TEENS



ANALYSIS OF VARIANCE:

SEX $F=23.34$ $p < .01$

GRADE $F=5.10$ $p < .01$

INTERACTION: NOT SIGNIFICANT

occupations than the females ($F = 12.15$, $p < .01$), and students became more interested in these occupations as they advanced in grade ($F = 3.71$, $p < .025$). An analysis of variance performed on the data from the Female Occupations Scale indicated that females were significantly more interested in these occupations than males ($F = 234.5$, $p < .01$).

Personality Adjectives

An adjective check list made up of "masculine", "feminine", and "neutral" adjectives was given to students as a measure of self-reported personality. The adjectives were taken primarily from Williams and Bennett (1975), the Bem Sex Role Inventory (1974), and Silvern (1977). Students were asked to rate themselves using each adjective on a five-point scale ranging from "almost always true" to "almost never true". A factor analysis of this data yielded four distinct factors:

1) Nurturance (affectionate, tender, emotional, gentle, sensitive, soft-hearted, and mild)
2) Bravery (adventurous, aggressive, courageous, daring, forceful, and tough)
3) Intellectual Achievement (independent, logical, realistic, smart, and ambitious)
4) Negative self (careless, complaining, moody, and nagging)

Each of the items on the Nurturance Scale have been documented as related to femininity in previous studies. An analysis of variance on the data from the present study using grade and sex as independent measures revealed significant sex ($F = 56.07$, $p < .01$) and grade main effects ($F = 4.39$, $p < .01$). The females scored higher on this scale than the males, and both males and females increased in nurturance with grade.

Each of the items on the Bravery Scale have been documented as related to masculinity in previous studies. An analysis of variance revealed a significant sex ($F = 19.69$, $p < .01$) main effect, with the males obtaining higher scores than the females.

Although each of the items except "smart" on the Intellectual Achievement Scale had been associated with masculinity in previous studies, an analysis of variance using the data from the present sample did not yield a significant sex main effect. The significant grade level effect ($F = 7.58$, $p < .01$) indicated that students obtained higher scores on this scale with increasing grade.

Items from the Negative Self Scale were not related to either masculinity or femininity in previous research, with the exception of "complaining" which was documented as feminine by Williams and Bennett (1975). An analysis of variance on the data obtained in the present study yielded no significant effects.

Family Aspiration

This variable was included in order to assess student commitment to future family life. The final Family Aspiration Scale was comprised of four items; two items were presented with four-choice Likert responses, and two items were presented with five-choice Likert responses. The data was converted to standardized scores for this scale only. An analysis of variance indicated that females showed a stronger commitment than males to family life ($F = 12.0$, $p < .01$). There was no significant grade main effect, nor was there a significant grade x sex interaction.

Peer Influences

Two scales were developed in order to assess the extent to which students were influenced by their peers. In the Peer-Academic Scale, three items

assessed student perceptions of peers reactions to academic success. Two items pertained to mathematics and one item pertained to English.

A second scale was developed to assess students' influence of peers when compared with parental influence. Three of these items factored together to form the Peer-Parent Scale.

Separate analysis of variance was performed on the scores from the two peer scales, using grade and sex as independent variables. No significant main effects or interactions were obtained.

Independence

Three items assessing students' independence of work style were included in the Independence Scale. Each of these items were presented in a five-point Likert format ranging from "strongly agree" to "strongly disagree". An analysis of variance revealed no significant grade or sex differences associated with this variable.

Math Usefulness

The Math Usefulness Scale was comprised of two subscales: math usefulness for boys and math usefulness for girls. Since the two subscales are conceptually distinct, they were examined separately. An analysis of variance on the Math Usefulness For Women Scale revealed a significant sex ($F = 10.176$, $p < .002$) and a marginally significant grade ($F = 2.75$, $p < .06$) main effect. The sex x grade interaction was significant ($F = 3.51$, $p < .03$). Relative to the females, the males responded that math is less useful for women. With grade, the males remain relatively constant in this response level, whereas with grade the girls perceive math as increasingly less useful. The Math Usefulness for Men Scale indicated a significant main effect of grade ($F = 3.14$, $p < .045$), with perceived usefulness for men increasing with grade.

In summary, the males perceive math as less useful for women than for themselves, and this perception remains constant across grade. The females,

however, see math as declining in usefulness for women, and remaining relatively constant for males. As they advance in grade, both males and females indicate that math becomes increasingly more useful for males.

Math Achievement

Correlation coefficients were calculated between scores obtained by students on the attitudinal and personality scales and their scores on their achievement tests in mathematics. For the combined sample of male students, achievement scores (percentiles) were positively correlated with Math Attitudes ($p < .01$), Usefulness ($p < .04$), interest in Male Occupations (p .01), Intellectual Achievement ($p < .01$), Negative Self ($p < .03$), and negatively correlated with Stereotyping ($p < .02$). For the combined sample of female students, achievement scores were positively correlated with Math Attitudes ($p < .01$), Usefulness ($p < .01$), Independence ($p < .01$), interest in Male Occupations ($p < .03$), and Intellectual Achievement ($p < .01$). Math scores of the females were negatively correlated with stereotyping ($p < .01$).

In addition, correlations were computed by grade and sex separately. That is, correlations were computed between scores obtained by students on the various scales and their mathematics achievement (scale) scores. These results indicated that the patterns of correlations varied depending on the students' grade level and sex (see Table 4). In general, the strength of the relationship between attitudes and achievement increased with grade level. Math Attitudes were highly correlated with math achievement for all students in all three grades. An interesting pattern of correlations was obtained for Math Usefulness. Math Usefulness for Women was positively related to math scores for the ninth and eleventh grade females, whereas Math Usefulness for Men was significantly correlated with math achievement scores of the eleventh grade males. Thus, math usefulness increases in importance with grade as a predictor of math achievement.

Table 4

Correlation Between Student Measures and Math Achievement Scores (scale scores) by Grade and Sex

	7th Grade		9th Grade		11th Grade	
	Male	Female	Male	Female	Male	Female
Task Competence Motivation (A)	.40**	.20*	.32**	.23**	.53**	.40**
Math Anxiety (B)	-.38**	-.27**	-.34**	-.37**	-.50**	-.40**
Math Attitude (A & B)	.44**	.24**	.35**	.38**	.55**	.43**
Stereotyping	-.22*	-.28**	-.12	-.38**	-.07	-.47**
Usefulness	.04	.10	.15*	.29**	.35*	.16
Women	.02	.08	.12	.30**	.26	.23*
Men	.13	.00	.17	.26**	.37*	.01
Peer Influence	-.18	-.19*	.08	-.08	-.27	-.46**
Independence	.32**	.26*	-.16	.14	.12	.28
Peer vs. Parent Influence	.05	.19	.11	.03	.02	.07
Family Aspiration	.09	.04	-.04	.13	-.44*	.10
Male Occupations	.26*	-.07	.31**	.09	.50**	.55**
Female Occupations	-.08	.11	.09	.04	.03	-.11
Nurturance	.05	-.10	.13	-.02	.07	.10
Bravery	-.14	-.33**	-.28**	.19*	.23	.04
Intellectual Achievement	.43**	-.35*	.14	.54**	.16	.26*
Negative Self	-.05	-.01	.30**	-.10	.11	.01

* $p < .05$
** $p < .01$

Peer Influence was inversely correlated with math achievement scores for the seventh and eleventh grade females. This finding was expected, indicating that social influences may be related to lowered math scores for females. It is not clear why this relationship did not hold for the ninth grade females. Interest in Male Occupations was positively correlated with math achievement for males at all grade levels and for the eleventh grade females. This finding may indicate that both males and females associate future career interests with increased proficiency in mathematics. This association seems to occur at an earlier developmental level for the males. The fact that math achievement was unrelated to Feminine Occupations may indicate that students do not perceive any relationship between mathematics and the fields on this scale.

Several interesting results emerged from the Personality Adjective Scales. Scores on the Bravery Scale were inversely correlated with math achievement for the seventh and ninth grade females and for the ninth grade males. This is, as interest in physical prowess increased, math scores decreased. Scores on the Intellectual Achievement Scale were positively related to female math achievement scores at all grade levels and to the achievement scores of the seventh grade males. It is not clear why Intellectual Achievement was not significantly correlated with math achievement for all students. Negative Self scores were positively correlated with math achievement for the ninth grade males only. That is, as negativity toward the self increased, math scores tended to increase.

Course Taking

No sex main effect was obtained in number of courses taken or intended to be taken in the future. There was a sex x grade level interaction ($p < .01$) in number of math courses to be taken in the future. For the seventh grade

Table 5

CORRELATIONS BETWEEN SELECTED ITEMS AND MATHEMATICS ACHIEVEMENT SCORES

	GRADE 7		GRADE 9		GRADE 11	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
HOW INTERESTED ARE YOU IN BECOMING A MATHEMATICIAN?	.36**	.04	.24*	.32**	.48**	.56**
WHAT GRADES DO YOU GET IN MATH?	.70**	.63**	.65**	.55**	.86**	.50**
HOW MANY MATH COURSES DO YOU INTEND TO TAKE IN THE FUTURE?	.13	.36**	.55**	.51**	.72**	.61**
HOW MANY MATH COURSES HAVE YOU TAKEN?	.00	.19	.06	.15	.42*	.37**

* $p < .05$

** $p < .01$

Table 6

CORRELATIONS BETWEEN SELECTED ITEMS AND MATH ATTITUDE SCORES

	GRADE 7		GRADE 9		GRADE 11	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
HOW INTERESTED ARE YOU IN BECOMING A MATHEMATICIAN?	.46**	.51**	.50**	.65**	.54**	.74**
WHAT GRADES DO YOU GET IN MATH?	.42**	.48**	.43**	.44**	.78**	.48**
HOW MANY MATH COURSES DO YOU INTEND TO TAKE IN THE FUTURE?	.36**	.06	.52**	.60**	.53**	.55**
HOW MANY MATH COURSES HAVE YOU TAKEN?	.00	.11	.15	.01	.42*	.34*

* $p < .05$

** $p < .01$

students, the females indicated that they intended to enroll in more future math courses than the males. For the ninth grade students, the males indicated that they intended to enroll in more future math courses than the females. The eleventh grade males and females indicated that they intended to enroll in approximately equal numbers of math courses in the future.

There was a strong and significant relationship between students' intentions to enroll in future mathematics courses and their mathematics achievement scores. The only exception to this pattern was for the seventh grade males. Number of courses taken and mathematics achievement scores were significantly correlated for males and females in the eleventh grade. In addition, the eleventh grade females showed significant inverse correlations between their scores on the Stereotyping Scale and number of math courses taken ($r = -.33$, $p < .01$) and number of math courses intended to be taken in the future ($r = -.36$, $p < .01$). These relationships did not reach significance ($p > .10$) for any other group of students.

Parent Measures

A short questionnaire was developed and mailed to parents of students who agreed to participate in the study. We received 94 completed questionnaires from mothers and 76 completed questionnaires from fathers.

The questionnaire contained measures assessing attitudes toward mathematics and stereotyping in mathematics. An analysis of variance indicated that fathers have more positive attitudes toward math and were more stereotypic in their responses.

A number of statistical analyses were carried out in order to determine the extent to which parent attitudes related to math attitudes and math achievement in their offspring (Table 7 & 8). For the male students, fathers'

Table 7

Correlations Between Parent Math Attitudes, Parent Stereotyping, and Student Achievement Scores (Mothers n = 95, Fathers n = 67)

	Male Students	Female Students
Father Attitude	.19	.05
Mother Attitude	.06	.17
Father Stereotyping	.05	.16
Mother Stereotyping	.02	.01

Table 8

Correlations Between Parent Math Attitudes, Parent Stereotyping, and Student Math Attitude Scores (Mothers N = 95, Fathers N = 67)

	Male Students	Female Students
Father Attitude	.33**	.17
Mother Attitude	-.09	.37**
Father Stereotyping	-.23*	-.22
Mother Stereotyping	-.23*	-.21*

* $p < .05$
** $p < .01$

attitude toward math was significantly correlated with sons' scores on the Math Attitude Scale ($p < .01$). For the female students, mother attitude toward math was significantly correlated with daughter's scores on the Math Attitudes Scale ($p < .01$).

For the male students, fathers' scores on the parent stereotyping measure were significantly correlated with sons' scores on the Stereotyping (see Table 8) Scale ($r = .23$, $p < .05$). Fathers' stereotyping was positively related to mothers' stereotyping ($r = .25$, $p < .05$).

For the female students, fathers' scores on the parent stereotyping measure were significantly correlated with daughters' scores on the Stereotyping Scale ($r = .23$, $p < .05$). Fathers' stereotyping was positively correlated to mothers' stereotyping ($r = .22$, $p < .05$).

Regression Analyses

When predicting math achievement scores using a step-wise regression model, Non-Language Aptitude was the strongest predictor of math achievement for both males and females. In addition, several of the personality and attitudinal scales were predictors of student achievement in mathematics.

For the males, using percentile math achievement scores as dependent variables, a hierarchical regression analysis indicated the Math Attitudes and interest in Male Occupations accounted for a significant proportion of the variance. For the females, scores on the Math Attitudes, Stereotyping and Intellectual Achievement Scales were the variables that accounted for a significant proportion of the variance. Predictions based on regression analyses were in some cases dependent upon the grade and sex of the students.

For the seventh grade males, scores on the Math Attitude Scale, Intellectual Achievement Scale and the Bravery Scale significantly predicted math achievement scale scores. For the seventh grade females, Stereotyping,

Bravery, and Intellectual Achievement were significant predictors. Scores on the Math Attitude Scale were only marginally predictive ($p < .06$) if entered as Step 1.

For the ninth grade males, scores on the Math Attitude and Bravery Scale were significant predictors of math achievement. For the ninth grade females, scores on the Math Attitude, Usefulness for Women, Intellectual Achievement, and Stereotyping scales accounted for significant portions of the variance.

For the eleventh grade males, scores on the Math Attitude scale were predictive of math achievement. For the eleventh grade females, scores on the Math Attitude Scale, Stereotyping Scale, Intellectual Achievement and Male Occupations Scale were predictive of math achievement.

Math Underachievement

An indication of student underachievement and overachievement in mathematics was obtained by subtracting math aptitude score from the same student's achievement score. Thus, discrepancy scores were calculated for each subject. Positive discrepancy scores indicate math overachievement and negative discrepancy scores indicate underachievement. An analysis of variance performed on discrepancy scores revealed no significant grade or sex effects. When discrepancy scores were correlated with attitudinal and other personality measures, however, an interesting pattern of results was obtained. For the males, math attitude correlated highly with discrepancy scores ($r = .38$, $p < .01$), as did interest in male occupations ($r = .22$, $p < .01$).
Father's attitudes toward mathematics correlated highly with son's discrepancy scores ($r = .38$, $p < .01$).

For the females, math attitudes also correlated significantly with discrepancy scores ($r = .25$, $p < .01$). Also, similar to the males, female interest in male occupations correlated significantly with their discrepancy

scores ($r = .16$, $p < .01$). In contrast to the males, female student discrepancy scores were significantly correlated with their own stereotyping of mathematics ($r = -.16$, $p < .01$). Father's attitude toward mathematics correlated significantly with daughter's discrepancy scores ($r = .37$, $p < .01$). There was a suggestion that father's stereotyping of mathematics related to some extent to daughter's discrepancy scores ($r = -.25$, $p < .057$).

These results suggest that, relative to expected level of student performance, overachievement is related to positive math attitudes, interest in male occupations, and positive math attitudes of fathers. For females, underachievement, that is, lower achievement scores than would be expected based on aptitude scores, was related to stereotypic beliefs of themselves and those of their fathers.

Differential cognitive abilities of elementary and secondary school children necessitated the development of two distinctly different questionnaires. Although these differences precluded direct comparisons of the two data sets in most cases, several specific items were presented to students in both elementary and secondary school, providing a comprehensive account of math attitudes from grades 3 to 11. Among the most interesting of these items were those designed to assess a liking of mathematics of self, friends, mothers and fathers.

These questions were all presented in a four choice Likert format and were as follows:

How much do you like mathematics?

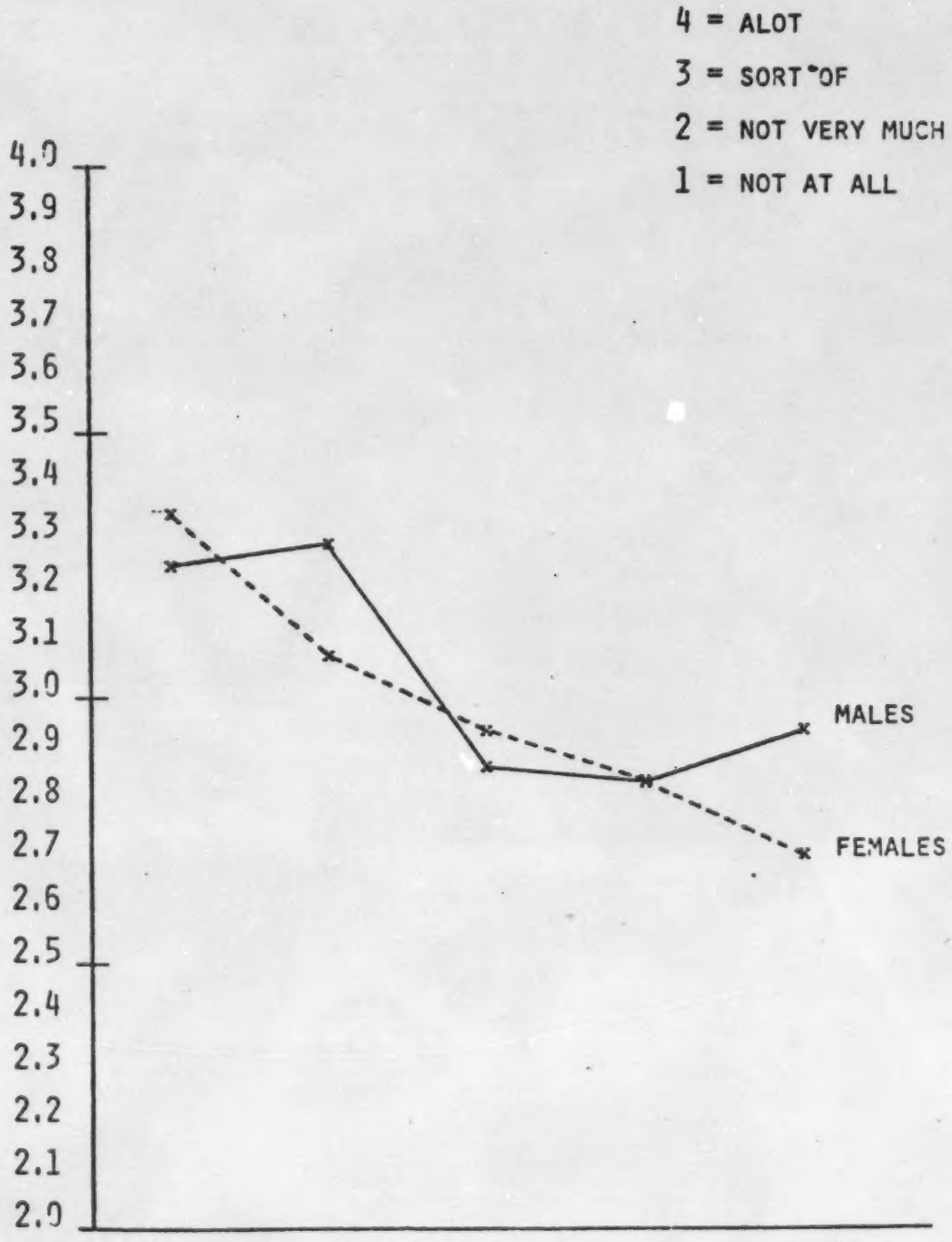
How much does your mother like mathematics?

How much does your father like mathematics?

How much do your friends like mathematics?

Figure 3

HOW MUCH DO YOU LIKE MATH?



	GRADES 3&4	GRADES 5&6	GRADE 7	GRADE 9	GRADE 11
N-COUNTS(M)	129	147	81	96	37
N-COUNTS(F)	154	128	77	111	51

Figure 4

MATH LIKING
SELF AND SIGNIFICANT OTHERS
MALES ONLY

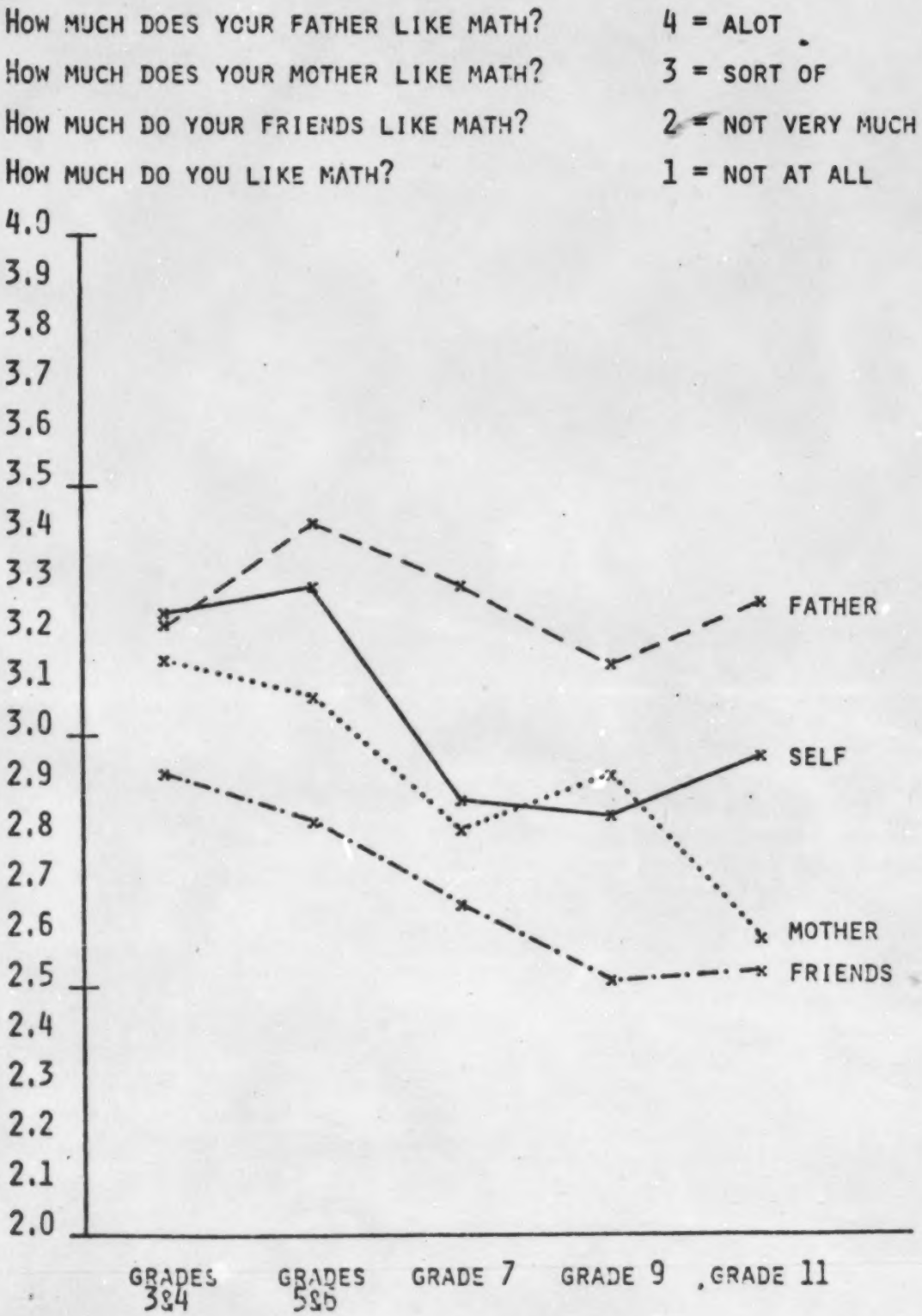
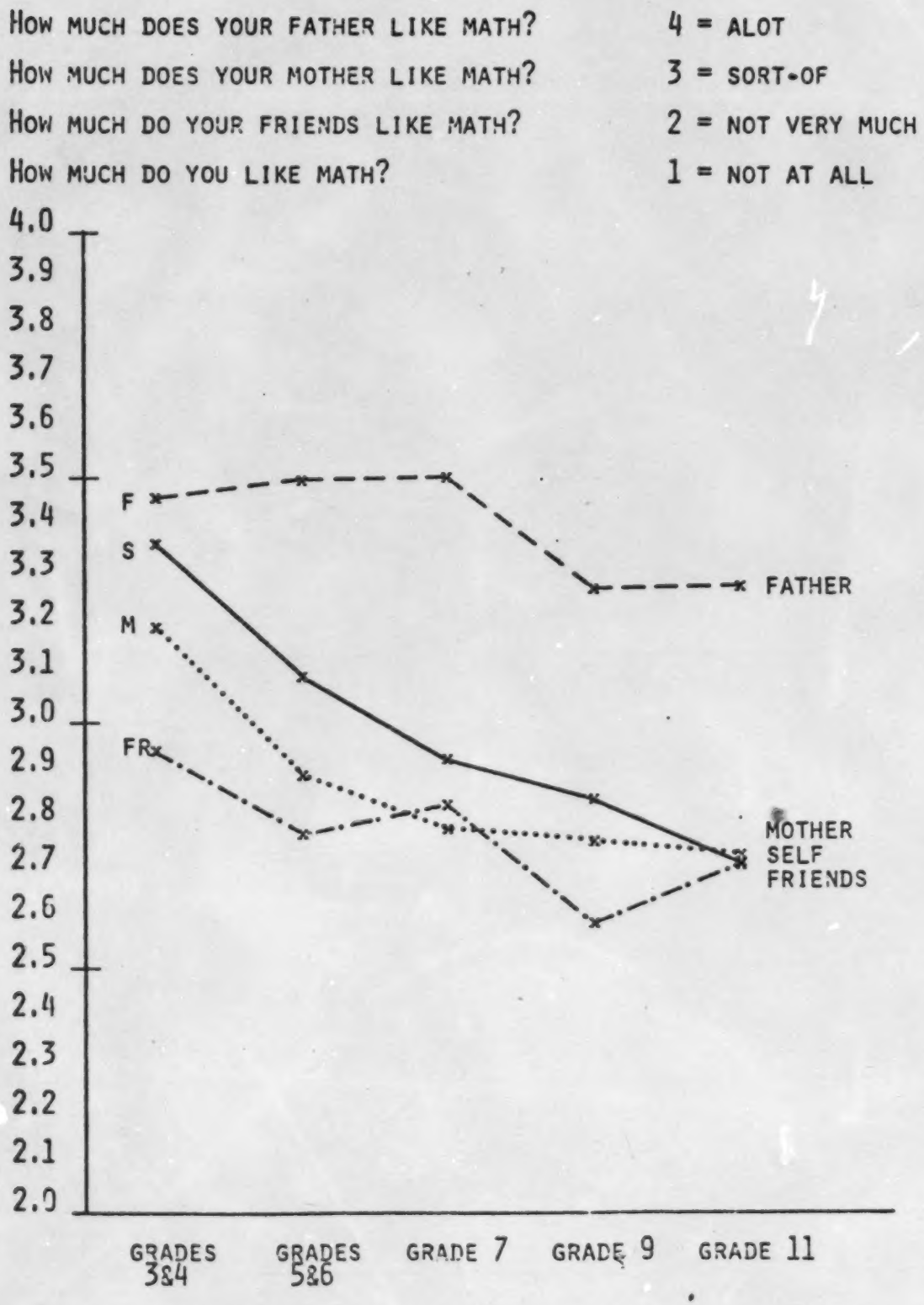


Figure 5

MATH LIKING
SELF AND SIGNIFICANT OTHERS
FEMALES ONLY



We obtained an interesting pattern of results with these items. When we asked students how much they liked math, both males and females showed a general decline with age. The eleventh grade males showed a slight increase in math attitudes relative to females (see Figure 3). On the two items dealing with mother and father liking of mathematics (Figure 4 & 5), we found a sharp decline in the older females' perceptions of their mothers' liking of mathematics. Both the older and younger females perceive that their fathers like math more than their mothers, and age did not affect their perceptions of their fathers' liking of math. The older and younger males also see their fathers and mothers liking math at more constant levels than the older and younger females.

Both males and females see their friends as liking math less than they themselves like math. One explanation is that students are more likely to give what they perceive to be socially desirable responses when indicating how much they like math than when they are reporting their friends' liking of math. A second explanation is that among elementary and secondary school, students expressing negativity about math is the "acceptable" way of behaving and expressing a positive attitude is unacceptable. Thus, many of the students may hold more positive attitudes than they lead their peers to believe. A correlation between self-liking of math and friends' liking of math was highly significant.

The fact that no sex differences were found in math achievement scores or discrepancies between achievement and aptitude was encouraging. The results of items dealing with course-taking in mathematics were complex. The fact that the seventh and ninth grade males and females have enrolled in the same number of math courses was not surprising since students are required to take math courses at these grade levels. Relative to the females,

the ninth grade males indicated that they intended to enroll in more math courses in the future. This result is consistent with previous results reported in the literature. It was puzzling that there were no sex differences in the number of math courses taken by students in the eleventh grade. The preliminary results of a survey of math classes in the Boulder Valley School District indicated that there are many more males than females currently enrolled in optional math courses. Thus, our eleventh grade sample may not be representative of students in the entire school district.

There were marked sex differences among our sample in attitudes toward math. Males held more positive attitudes toward math and both male and females showed a decline in math attitudes with grade. Math attitudes were related to student discrepancy scores (whether a student overachieves or underachieves relative to expected achievement level as demonstrated by their math aptitude).

There was a strong relationship between stereotyping and math performance. Moreover, stereotyping was related to underachievement in girls--that is, the higher the level of stereotyping, the lower the math achievement score. Moreover, stereotyping was associated with underachievement in mathematics. On an open-ended item, several students indicated their belief that stereotypes were lessening.

The data from the parent questionnaire indicated that mothers' math attitudes were more significantly related to daughters' math attitudes. Fathers' stereotyping scores affected student attitudes and achievement in mathematics. This influence was highly related to daughter's underachievement or overachievement in mathematics. Peer influences seemed to affect the eleventh grade females to a greater extent than students in other grades. Thus, to some degree, both parents and peers affect math achievement among high school students.

Mathematics achievement was related to the perceived usefulness of mathematics, as well as to students' interest in occupations traditionally associated with males.

In summary, the results of the study on secondary students indicated that:

1) Males are more positive than females in their attitudes toward math.

2) Math attitudes decline with grade for the females; for the males, math attitudes increase somewhat between the ninth and eleventh grades.

3) Female math attitudes were significantly related to their mothers' math attitudes; male math attitudes were significantly related to their fathers' math attitudes.

4) Males at all grade levels hold more stereotypic beliefs than females.

5) Attitudes toward math are predictive of math achievement scores for both males and females. For the females, stereotypic beliefs, interest in male occupations and perceived usefulness of math were predictive of math achievement.

Conclusions

The results of this research clearly indicate that there are a number of stereotypic attitudes about women and mathematics that are culturally pervasive. The hypothesis that the degree to which these negative beliefs are held is inversely related to mathematics achievement was supported by the data obtained in this study. Stereotypes associated with mathematics are learned by children at a very young age, and this knowledge affects their participation and performance in mathematics.

There are two categories of stereotypes associated with mathematics. The first is a broad, general characterization of the field itself, namely, that mathematics has been traditionally considered a very masculine subject. The second category includes more specific stereotypes pertaining to women who dare to venture into this supposedly masculine domain.

It is important to note, however, that these beliefs are not equally salient at all points in the developmental cycle. The various components of mathematical stereotyping are introduced at different times, and by different agents. For example, the notion that adult women are generally inferior to adult men in mathematics was present in our sample of elementary school children. Thus, mathematics is put forth as a male domain extremely early during development. However, children perceived this stereotype as a characteristic associated only with the adult world. They apparently do not identify closely with these sex differences, and their mathematics achievement scores were not affected.

These findings have implications for the general self-esteem for both males and females. For females, development brings with it an increasing

perception of themselves as incompetent in math relative to males. This change may be accompanied by a lowering of self-esteem. For males, there are few changes in their perceptions of their own abilities and involvement in mathematics, thus their self-esteem in not affected.

The agents transmitting stereotypic information is dependent on the grade level of the student, with peer groups appearing to play increasingly potent roles as students advance in grade. The female mathematicians who completed our questionnaire indicated that they first became aware of the presence of negative perceptions and beliefs about women's involvement in mathematics during secondary school, primarily from their male peers.

The relevance of mathematics to career choice becomes particularly significant at the high school level. In the present study, math achievement scores of the females were related to interest in traditionally masculine occupations. This relationship increased with grade level. Furthermore, math is perceived as more or less useful, depending on its relevance for career choice. It may be speculated that the stereotype that a career in mathematics conflicts with family goals may not be fully experienced until college. One of the hypotheses initially advanced was that women would internalize negative stereotypes so that they became part of their own belief systems. What this research shows is that although women do indeed hold stereotypic beliefs, males hold them even more strongly. Many female mathematicians in our sample indicated that they had witnessed discrimination among their female colleagues. Although women are to some extent a victim of their beliefs and therefore act to some degree as their own deterrents in pursuing careers in mathematics, external barriers in the form of discrimination and negative stereotyping on the part of males still exist which deter many women from pursuing interests in mathematics.

The implications of these results are particularly relevant for parents and educators. Since the data indicate that children reveal stereotypic beliefs about mathematics as early as the third grade (and no doubt even younger), it is apparent that parents and educators need to adopt non-stereotyped attitudes and expectations when dealing with children. Women do not need to be encouraged to enroll in math courses as much as they need to be expected to enroll in math courses. Text books and course curricula must be designed so to be free from any suggestion that women are not proficient or are not equal participants in the mathematics realm. The importance of appropriate role models, both in teaching materials, and teacher, cannot be over-estimated. Psychologists have argued for some time about whether it is more effective to change the attitude before the behavior or change the behavior and as a result change the attitude. It may well be the case for women in mathematics that behavioral changes must come about first.

In summary, the results of this study support the thesis that women's underrepresentation in mathematics is related to the larger issue of sexism in society. Not until women are encouraged to pursue their own interests and fulfill their own potentials without artificially imposed restraints, will equity in the field of mathematics be attained.

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Appendix

Note: Items were reversed so that higher scores indicated higher interest or intensity in variable.

Measures for Study 1: Ph.D. Study

Stereotyping Questions (Ph.D. Study)

1. Do you think that the general public holds stereotypes about women in the profession in which you obtained your Ph.D.? (YES NO)

2. If you answered "no", skip to #3 on the following page.
   If you answered "yes", continue with the next item.

   a. List these stereotypes. Please be as specific as possible.

   b. At what age (approximately) did you become aware of these stereotypes?

   c. Recall as best you can the source(s) of this information. Check as many as would apply.

   d. To what degree do you think the stereotypes people generally hold regarding women in the profession in which you obtained your Ph.D. are accurate characterizations of these women?

3. To what extent did you hold stereotypes about women in the profession in which you obtained your Ph.D. during grades 7-12?

4. How many men in the profession in which you obtained your Ph.D. hold stereotypes regarding the women in that profession?

5. In general, society tends to characterize specific careers as "feminine" or "masculine". In what category would society categorize the field in which you obtained your Ph.D.?

6. At what age did you become aware of this categorization (skip if you answered "neither feminine nor masculine")?

7. Do you think women who enter traditionally "masculine" fields are negatively affected by this stereotyping?

8. If yes, in what way are women negatively affected?

9. Do you think masculine or feminine stereotyping of the field in which you obtained your Ph.D. is changing?

10. If you answered that masculine or feminine stereotyping is becoming weaker, why do you think this is so? Rank answers by putting a "1" beside the most important reason, a "2" beside the second most important reason, etc. Rank only those items you think are having an effect.

11. How often have you been aware that you have been discriminated against as a woman in your profession?

12. How often have you seen women that you knew personally discriminated against in your profession?

Locus of Control Scale

1. In my profession, getting a good job depends mainly on being in the right place at the right time.

2. Generally speaking, my behavior is not governed by the actions or opinion of others.

3. Getting ahead in my field is largely the result of competence and effort.

4. There is a large element of luck involved in attaining one's goals and ambitions.

5. There is really no such thing as "luck".

6. At times I feel that I have little influence over the things that happen to me.

7. Heredity plays the major role in determining one's personality.

8. It is a person's experiences in life which determine a person's personality.

Measures for Study 2: Elementary Study

Toys and Activities - Elementary School

Masculinity Scale	Femininity Scale
skateboard	sewing kit
boxing	working in the kitchen
go cart	flute
football	knitting
baseball	dolls
drums	ball and jacks
model airplane	ice skates
chess	go shopping
woodworking	gardening
train set	

Math Attitude Scale - Elementary School

Factor Loading	Item No.	
.79077	(3) 11	How often is math fun for you? (always, usually, sometimes, never)
.80325	(3) 13	How often is math interesting to you? (always, usually, sometimes, never)
.82812	(3) 15	How much do you like math? (a lot, sort of, not very much, not at all)
.70820	(3) 16	Which of these is true for you? (Math is my best subject . . . worst subject)
.30383	(3) 18	How hard is math for you? (not hard at all, not too hard, pretty hard, very hard)

Peer Math Attitudes - Elementary School

Factor Loading	Item No.	
.56468	(3) 29	How much do your friends like math? (a lot, sort of, not very much, not at all)
.70732	(3) 32	How important do your friends think math is? (very important, pretty important, not too important, not important at all)

Stereotyping Adults Scale - Elementary School

3.* Who can work with numbers best, Mr. or Mrs. Hill?

5.* Mr. and Mrs. Morgan got a new hand calculator. Who uses it most, Mr. or Mrs. Morgan?

11.* Dad and Mom are working on their taxes. Who is better at figuring out how much they have to pay, Mom or Dad?

* These questions were accompanied by simple drawings depicting each situation.

Measures for Study 3: Secondary School

MATH ATTITUDE SCALE

Subscale A: TASK COMPETENCE MOTIVATION

Factor Loading	Item No.	
.52057	18	I don't feel much of a sense of accomplishment when I learn new mathematics skills. (mastery)
.72158	22	I like to work on mathematics problems just for the sheer joy of it. (effectance)
.60242	23	I do not enjoy figuring out the solution to mathematics problems on my own. (autonomy)
.64800	28	I like adding to my mathematical skills. (mastery)
.66081	58	When I do mathematics problems, I almost never get really involved in the material. (effectance)
.47824	62	I like to work on mathematics problems without help from anyone. (autonomy)
.45783	111	I don't often do mathematics problems just for the sheer joy of it. (effectance)
.76798	118	Mathematics fascinates me. (effectance)

Subscale B: MATH ANXIETY

.62261	19	It doesn't upset me to work on mathematics problems.
.53642	25	Working mathematics problems makes me feel scared.
.53386	34	I haven't minded being called on in the mathematics classes I've taken.
.45389	96	In the mathematics classes I have taken, I have gotten a sinking feeling when I was called on.

MATH STEREOTYPING SCALE

Factor Loading	Item No.	
.44320	98	Most boys look down on girls who get good grades in mathematics.
.59333	125	Mathematics is not useful for girls.
.44935	31	Most girls can't think logically enough to do well in mathematics.
.50099	101	Most adult women aren't very good in mathematics.
.53270	122	Most girls are not good at algebra.
.61030	57	Mathematics is not a good place for a woman to use her talents.
.57540	93	A girl should be as free to go into mathematics as any other field.
.67442	95	Girls do not really belong in mathematics classes.
.58927	126	Women belong in mathematics if they so choose.
.45451	121	Women should enter a field other than mathematics.
.49027	14	Female mathematicians are unfeminine.

Math Usefulness Scale

Subscale A: Math Usefulness for Women

Factor Loading	Item No.	
.50594	11	It is useful for a woman to have a good mathematics background.
.66934	30	Girls will probably need mathematics for the future.
.72407	51	Mathematics is important to a girl's future education.

Subscale B: Math Usefulness for Men

Factor Loading	Item No.	
.72231	66	It is useful for a man to have a good mathematics background.
.65429	116	Boys will probably need mathematics for the future.
.64305	99	Mathematics is important to a boy's future education.

PEER INFLUENCE

Factor Loading	Item No.	
.59336	39	It bothers me when other students know that I got good grades in mathematics.
.59287	109	It makes me feel uncomfortable when the other students know that I've done well on a mathematics test.
.48849	114	I do not like to appear too smart in English in front of the other students.

INDEPENDENCE IN WORK STYLE

Factor Loading	Item No.	
.63295	16	I like working on things by myself.
.67237	90	It bothers me to work alone.
.77482	128	I enjoy working alone.

PEER VS. PARENT INFLUENCE

Factor Loading	Item No.	
.52655	50	When you are feeling really excited about mathematics, who would you prefer to share it with, your parents or your friends?
.61382	86	If you were feeling really good about your math grades, who would you prefer to tell, your friends or your parents?
.46905	106	If you were deciding whether or not to take an optional ma h course, who would you prefer to ask for advice, your parents or your friends?

FAMILY ASPIRATION SCALE

Factor Loading	Item No.	
.53673	5	How important will getting married be to you in the future?
.63719	41	If you had to choose between having a good job or getting married, how much would you want the job?
.76818	71	I want to have a family more than I want a job or a career.
.88320	97	I want to have a job or career more than I want a family.

Personality Adjective Scales

Nurturance	Bravery	Intellectual Achievement	Negative Self
affectionate	adventurous	independent	careless
tender	aggressive	logical	complaining
emotional	courageous	realistic	moody
gentle	daring	smart	nagging
sensitive	forceful	ambitious	
soft-hearted	tough		
mild			

Occupation Scales

Traditionally performed by men	Traditionally performed by women
engineer	social worker
bus driver	dancer
police officer	head nurse
real estate sales	English professor
accountant	writer
mathematician	secretary
plumber	bookkeeper

Parent Attitude Scale

Item No.	
10	I find mathematics intriguing.
12	I tend to avoid situations in which mathematics is involved.
15	Mathematics was one of my favorite subjects in school.
24	I always dreaded doing mathematics homework.
28	I am comfortable doing calculations in mathematics.
31	Mathematics is boring to me.

Parent Stereotyping Scale

Item No.	
9	Girls should take as many optional math courses as possible in high school.
11	Mathematics is too difficult for most women.
16	Most girls will probably not need much mathematics in the future.
17	Most women can learn complex mathematical skills.
23	Most women have the ability to be good mathematicians.
26	The kind of work most girls will do in the future probably won't require a good mathematics background.
30	Most women are not capable of learning mathematics.